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Major article

Prevalence and risk factors for methicillin-resistant *Staphylococcus aureus* in an HIV-positive cohort

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Background: Persons living with HIV (PLWH) are disproportionately burdened with methicillin-resistant *Staphylococcus aureus* (MRSA). Our objective was to evaluate prevalence and risks for MRSA colonization in PLWH.

Methods: Adults were recruited from Johns Hopkins University AIDS Service in Baltimore, Maryland. A risk questionnaire and specimen collection from anatomic sites with culture susceptibility and genotyping were completed. Generalized estimating equation modeling identified MRSA colonization risk factors.

Results: Of 500 participants, most were black (69%), on antiretroviral therapy (ART) (87%), with undetectable viral loads (73.4%). Median CD4 count was 487 cells/mm^3 (interquartile range, 316-676.5 cells/mm^3). MRSA prevalence was 15.4%, predominantly from the nares (59.7%). Forty percent were nares negative but were colonized elsewhere. Lower odds for colonization were associated with recent sexual activity (adjusted odds ratio [AOR] = 0.84, $P < .001$) and ART (AOR = 0.85, $P = .011$). Increased odds were associated with lower income (<$25,000 vs >$75,000; AOR = 2.68, $P < .001$), recent hospitalization (AOR = 1.54, $P < .001$), incarceration (AOR = 1.55, $P < .001$), use of street drugs (AOR = 1.43, $P < .001$), and skin abscess (AOR = 1.19, $P < .001$).

Conclusions: Even with high MRSA prevalence, the proportion identified through nares surveillance alone was low, indicating the importance of screening multiple anatomic sites. Associations were not found with same-sex coupling or black race. MRSA prevention might be a benefit of ART in PLWH.

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Methicillin-resistant *Staphylococcus aureus* (MRSA) continues to cause excess morbidity and mortality among persons living with HIV (PLWH). In the United States, PLWH have substantially higher incidence of MRSA infections than the general population (12.3/1,000 person years compared with 1-2/1,000 person years),[1] and MRSA remains a substantial reason for hospital admission.[2] Metropolitan areas throughout the country have documented a substantial increase in MRSA infections,[3-5] peaking in 2008, with an incidence 5 times greater in PLWH than HIV-uninfected persons within a large health care system.[6] Despite recent reported declines in skin and soft tissue infection, PLWH continue to shoulder a disproportionate burden of disease.[7]

Key risk factors for MRSA colonization and infection have been identified as a result of these data and include substance abuse[8,9]; high-risk sexual practices in persons with greater numbers of sex partners, regardless of sexual orientation[10]; and having a sexual partner with a known skin infection.[10] Additional risks for MRSA infection among PLWH include male sex,[7] incarceration history,[7] lower CD4 counts,[4,5,10] high viral load,[4,11] recent hospital admission,[12] β-lactam antibiotic use,[3] lack of

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cotrimoxazole prophylaxis,[5,11] and known MRSA infection in the last 12 months.[3]

Despite recent attention to this issue, many questions related to the HIV-MRSA interface remain unanswered. To further understand risk and enable the improvement of this population's health and well-being and limit the spread of MRSA within and among partners, this study assessed the overall prevalence of MRSA colonization at multiple body sites among PLWH and their primary partners. In addition, we determined the risk factors that are associated with MRSA colonization.

METHODS

Study setting and participant selection

To assess colonization prevalence among PLWH, we conducted a cross-sectional epidemiologic evaluation of MRSA among persons within the Johns Hopkins University AIDS Service (JHUAS). The JHUAS is a hospital-based practice that provides specialty care at the Moore Clinic on the Johns Hopkins Hospital campus in downtown Baltimore, Maryland, and at Green Spring Station (GSS) in Baltimore County. Urban Baltimore has a high incidence of HIV infection and MRSA colonization within outpatient populations.[13,14] Greater than 50% of our clients reside in East Baltimore and >75% are within the city limits. The Moore Clinic follows an average of 2,000 clients annually, including the uninsured, with most residing in Baltimore City. Most are black (77%), with major HIV transmission risks of intravenous drug use and heterosexual sex. Colocated services include viral hepatitis clinic, counseling, case management, social work, laboratory services, wound care, and an outpatient pharmacy. The GSS medical office serves a smaller patient cohort ($n = 650$) that is primarily white (64%), with a greater proportion residing in Baltimore's surrounding counties. The major HIV transmission risk at GSS is men who have sex with men. The GSS Clinic also provides services to persons without HIV infection and does not accept the uninsured. There is an onsite laboratory and outpatient pharmacy. Many providers work at both the GSS and Moore Clinic locations.

Sample size calculations were informed by previous work showing a strong association between MRSA and previous or current abscess[15] along with community prevalence data for Baltimore City. Based on the projected probability of MRSA among persons with abscess (0.30) and the probability of abscess in the entire cohort (0.18), a sample size of 500 was needed to obtain 90% power at $\alpha = 0.05$ for a 2-tailed test. This sample size would allow us to detect associations between having a current abscess and MRSA colonization.

Subjects were recruited from March 1, 2010-June 30, 2010, with microbiologic analysis completed in April 2011. Eligible primary subjects were adult men and women ages ≥18 years with the ability to read or understand spoken English who receive care within the JHUAS. Potential participants were approached and screened consecutively during the recruitment period: every tenth patient entering the Moore Clinic and all patients at GSS. We gathered specimens from sexual partners to examine similarities and differences between partners and MRSA colonization. Sexual partners were eligible for inclusion if referred by the index HIV-positive subject, regardless of the partner's HIV status. Participants were offered a $25 gift card for participation. The study was approved by the Johns Hopkins Medicine Institutional Review Board.

Collection of clinical specimens

A total of 6 swabs for men and 7 for women were collected, plus an additional swab for anyone with a wound. Anterior nares, axillary, throat, groin, perineum, and rectal swabs were obtained using BactiSwab II dual-headed culturettes (Remel, Lenexa, KS). The perineum is the area between the anus and scrotum or vulva. Vaginal swabs were collected on both women and postoperative transgendered women. Wound specimens were obtained from any patient presenting with an open or draining wound. Two trained registered nurses collected all patient swabs. All swabs were collected during the clinic visit at study enrollment, transported at room temperature, and stored at 5°C until processing within 24 hours of collection.

Risk factor evaluation

A survey instrument was designed with a set of questions used in a questionnaire previously implemented within the same population to assess factors related to a person's hospital and community risks for MRSA acquisition. Another 13 questions were added to assess behavioral risk factors, leading to a 64-item questionnaire. The current study did not evaluate all 64 items. A study team member administered the questionnaire face-to-face during the clinic visit at study enrollment. Interviewers were trained in sexual history taking and pilot tested the survey instrument. Interviews were conducted in a private setting, and confidentiality of responses was ensured to address the tendency for subjects to provide socially desirable responses. Both clinic populations are routinely screened for sexually history and sexually transmitted infections at each clinic visit. The time frame for any sexual activity or drug use was the 12 months prior to the interview. Medical records were reviewed by research nurses for clarity of HIV-related or sexual history, comorbidities, admission data, and other self-reported information from the questionnaire. Information from medical records was used if discrepancies occurred with self-reported information.

Microbiologic evaluation

Using standard culture methods, a swab was streaked onto CHROMagar MRSA (BD Diagnostics, Sparks, MD) [CHROM-MRSA], a selective medium, and then placed in Trypticase soy broth with 6.5% NaCl. Gram-positive cocci that were catalase positive and latex agglutination positive were identified presumptively as *S aureus*. The presumptive *S aureus* isolates recovered from the enrichment broth were subbed and sent to the BD Phoenix Automated Microbiology System (BD Diagnostics, Sparks, MD)[16] for identification and susceptibility testing when the matching CHROM-MRSA agar plates were negative. All isolates growing on CHROM-MRSA were considered MRSA.

Staphylococcal genotyping was performed using the Ibis Staphylococcus Typing and Characterization kit (Ibis Biosciences, Carlsbad, CA). This multiplex, broad-based, molecular assay, performed in a microtiter plate format, uses primer sets that are capable of identifying *S aureus* (*tufB* and *nuc*) and distinguishing MSSA from MRSA (*mecA*). It also incorporates primers that determine the presence of Panton-Valentine leukocidin genes (LukS and LukD), toxic shock toxin 1 (TSST1), and high-level (*mupA*) and low-level (*ileS*) mupirocin resistance. Strain characterization is performed by multilocus sequence typing using a unique set of sequences from 7 common housekeeping genes for *S aureus*. The assay is based on the principle of polymerase chain reaction (PCR)—electrospray ionization mass spectrometry (ESI-MS) and is performed on the Ibis T5000 instrument (Ibis Biosciences, Carlsbad, CA).[17,18] The assay was performed according to the manufacturer's instructions and interpreted according to the guidelines in the reference by Wolk et al.[18]

Table 1
Summary statistics of study measures

Characteristics	Overall sample (N = 500)	Green Spring Station (n = 150)		Moore Clinic (n = 350)	
		MRSA negative (n = 136)	MRSA positive (n = 14)	MRSA negative (n = 287)	MRSA positive (n = 63)
Sex					
Male	330 (66.0)	113 (83.1)	13 (92.9)	173 (60.3)	31 (49.2)
Female	170 (34.0)	23 (16.9)	1 (7.1)	114 (39.7)	32 (50.8)
Race					
Black	345 (69.0)	36 (26.5)	3 (21.4)	254 (88.5)	52 (82.5)
Other	13 (2.6)	7 (5.2)	1 (7.1)	4 (1.4)	1 (1.6)
White	142 (28.4)	93 (68.4)	10 (71.4)	29 (10.1)	10 (15.9)
Education					
No high school or GED	131 (26.2)	0 (0)	0 (0)	103 (35.9)	28 (44.4)
High school or GED	143 (28.6)	14 (10.3)	2 (14.3)	109 (38.0)	18 (28.6)
Some college-vocational	111 (22.2)	42 (30.9)	5 (35.7)	52 (18.1)	12 (19.1)
College graduate or more	115 (23.0)	80 (58.8)	7 (50.0)	23 (8.0)	5 (7.9)
Yearly income					
<$25,000	351 (70.5)	24 (17.9)	3 (21.4)	264 (92.0)	60 (95.2)
$25,001-$50,000	62 (12.5)	37 (27.6)	6 (42.9)	17 (5.9)	2 (3.2)
$50,001-$75,000	46 (9.2)	36 (26.9)	3 (21.4)	6 (2.1)	1 (1.6)
>$75,000	39 (7.8)	37 (27.6)	2 (14.3)	0 (0)	0 (0)
Been arrested					
Yes	40 (8.0)	4 (2.9)	0 (0)	26 (9.1)	10 (15.9)
No	460 (92.0)	132 (97.1)	14 (100)	261 (90.9)	53 (84.1)
Hands-on customer contact job					
Yes	94 (18.8)	49 (36.0)	4 (28.6)	39 (13.6)	2 (3.2)
No	406 (81.2)	87 (64.0)	10 (71.4)	248 (86.4)	61 (96.8)
Sexual orientation					
Different sex	315 (63.0)	95 (69.9)	8 (57.1)	69 (24.0)	13 (20.6)
Same sex-both sexes	185 (37.0)	41 (30.1)	6 (42.9)	218 (76.0)	50 (79.4)
Substance abuse (yes to street drugs)*					
Yes	253 (50.6)	31 (22.8)	4 (28.6)	173 (60.3)	45 (71.4)
No	247 (49.4)	105 (77.2)	10 (71.4)	114 (39.7)	18 (28.6)
Sexually active*					
Yes	336 (67.2)	111 (81.6)	11 (78.6)	177 (61.7)	37 (58.7)
No	164 (32.8)	25 (18.4)	3 (21.4)	110 (38.3)	26 (41.3)
No. of sex partners in last 30 d					
0	220 (44.3)	50 (36.8)	4 (28.6)	133 (46.3)	33 (52.4)
1	240 (48.3)	70 (51.5)	7 (50.0)	135 (47.0)	28 (44.4)
≥2	37 (7.4)	16 (11.8)	3 (21.4)	16 (5.7)	2 (3.2)
STI†					
Yes	16 (3.2)	8 (5.9)	1 (7.1)	6 (2.1)	1 (1.6)
No	484 (96.8)	128 (94.1)	13 (92.9)	281 (97.9)	62 (98.4)
Current abscess					
Yes	39 (7.8)	9 (6.6)	2 (14.3)	22 (7.7)	6 (9.5)
No	461 (92.2)	127 (93.4)	12 (85.7)	265 (92.3)	57 (90.5)
Prior abscess*					
Yes	67 (13.4)	16 (11.8)	2 (14.3)	38 (13.2)	11 (17.5)
No	433 (86.6)	120 (88.2)	12 (85.7)	249 (86.8)	52 (82.5)
Hospitalized*					
Yes	142 (28.5)	25 (18.4)	2 (14.3)	85 (29.7)	30 (47.6)
No	357 (71.5)	111 (81.6)	12 (85.7)	201 (70.3)	33 (52.4)
On isolation‡					
Yes	86 (17.3)	17 (12.8)	2 (14.3)	55 (19.2)	12 (19.0)
No	410 (82.7)	116 (87.2)	12 (85.7)	231 (80.8)	51 (81.0)
HIV medication					
Yes	430 (86.7)	125 (92.6)	14 (100)	242 (84.9)	49 (79.0)
No	66 (13.3)	10 (7.4)	0 (0)	43 (15.1)	13 (21.0)
On prophylaxis§					
Yes	86 (17.3)	11 (8.1)	0 (0)	59 (20.8)	16 (25.4)
No	411 (82.7)	125 (91.9)	14 (100)	225 (79.2)	47 (74.6)
Viral load					
Undetectable	367 (73.4)	115 (84.6)	14 (100.0)	196 (68.3)	42 (66.7)
Detectable	133 (26.6)	21 (15.4)	0 (0)	91 (31.7)	21 (33.3)
CD4 count					
<200	58 (11.6)	5 (3.7)	0 (0)	42 (14.6)	11 (17.5)
201-350	92 (18.4)	20 (14.7)	0 (0)	55 (19.2)	17 (27.0)
351-500	113 (22.6)	27 (19.9)	6 (42.9)	69 (24.0)	11 (17.4)
>500	237 (47.4)	84 (61.8)	8 (57.1)	121 (42.2)	24 (38.1)

NOTE. Values are n (%). Missing: hospitalized (n = 1), isolation (n = 4), prophylaxis (n = 3), income (n = 2), HIV medication (n = 4), and number of sex partners in 30 days (n = 3).

GED, General Educational Development; *MRSA*, methicillin-resistant *Staphylococcus aureus*; *STI*, sexually transmitted infection.

*Within previous 12 months.

†Within previous 6 months.

‡On any type of isolation during any previous hospitalization.

§Prophylaxis for HIV-associated opportunistic infections includes any use of trimethoprim-sulfamethoxezole, dapsone, azithromycin, or fluconazole.

Statistical methods

Descriptive statistics were computed on all study variables. Frequency distributions were used to summarize categorical variables, and measures of central tendency and dispersion were used to summarize continuous variables. Statistical models were constructed to model MRSA status as a function of demographic, behavioral, and clinical characteristics. Because between-site differences in this multisite study were substantial, we accounted for them with the implementation of generalized linear models with an unknown within-site correlation structure. Model parameters were estimated using generalized estimating equations (GEEs). Bivariate associations between all variables and the outcome of MRSA status were examined in unadjusted GEE models. A multivariable-adjusted model was chosen based on clinical relevance, statistical significance, and quasi-likelihood under the independence model criterion. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported. The data analysis was generated using SAS software version 9.3 of the SAS System for Windows (SAS Institute, Cary, NC).

RESULTS

Study population characteristics

Table 1 lists the characteristics of the participants in the study. All were HIV positive. Of those participating, most (87%) were on HIV medications. Participants' median CD4 count was 487 cells/mm^3 (interquartile range, 316-676.5 cells/mm^3), with 11.6% (n = 58) enrolled with a CD4 count <200 cells/mm^3; most (73.4%; n = 367) had an undetectable viral load at enrollment.

Of the study's 500 participants, 66% were men and 69% were black. Although most participants had received at least a high school education (74%), most (71%) also had an annual income of <$25,000. Over half of the participants reported sexual activity within the previous 12 months (67%). Almost two-thirds identified as heterosexual (63%).

Isolate characteristics

A total of 217 MRSA isolates from 77 individuals were identified and characterized with PCR ESI-MS technology. Of those, 86.2% were identified as a USA 300 strain type. The remaining 13.8% of the isolates included strain types USA 100, 700, 900, 1000, and 200/1100. The rates for Panton-Valentine leukocidin (PVL) genes (LukS and LukD), TSST1, and high-level (*mupA*) mupirocin resistance were 77.4%, 5.1%, and 2.8%, respectively. No isolates exhibited low-level (IleS) mupirocin resistance. All isolates positive for both mupirocin resistance and PVL were identified as USA 300 strain type, whereas the TSST1 positive isolates were a mix of both USA 300 and USA 100 strains. Of all 217 MRSA isolates from the 77 individuals, the proportions were highest for the nares (21.2%) and throat (20.7%), followed by the rectum (16.1%), groin (15.2%), perineum (15.2%), vagina (5.1%), axilla (4.1%), and wound (2.3%).

MRSA colonization by body site

Among 77 individuals with MRSA colonization (15.4% prevalence), the most common anatomic sites were nares of 46 individuals (59.7%) and throat of 45 individuals (58.4%) (Table 2). Forty eight (62.3%) of those colonized were culture positive at >1 site, and only 1 individual was colonized with multiple strain types. Thirty-one individuals (40.3%) were culture negative from the nares but were found to be colonized with MRSA at another anatomic site. Among those with MRSA colonization, the number colonized at only 1 site was 29 (37.7%), whereas 20 were colonized at 2-3 sites (26.0%), 22 were colonized at 4-5 sites (28.6%), and 6 individuals were colonized at ≥6 sites (7.8%). Two-sided Fisher exact tests were performed to examine associations between MRSA colonization sites and sexual activity in the prior 12 months and found not to be associated with the throat ($P = .318$), perineum ($P = .563$), groin ($P = .702$), vagina ($P = .533$), or rectum ($P = .850$). The prevalence of USA300 strains was high across all body sites, ranging from 81.8% for vaginal sites and up to 94.1% (n = 32) for rectal sites. All 5 wounds colonized with MRSA were USA300 strains.

Table 2
MRSA prevalence among body sites by nares result

Positive body site	Nares negative (n = 454)	Nares positive (n = 46)	Total positive (n = 77)	USA300 positive* (n = 66)
Nares	NA	NA	46 (59.7)	39 (84.8)
Throat	15 (3.3)	30 (65.2)	45 (58.4)	37 (82.2)
Rectal	11 (2.4)	23 (50.0)	34 (44.2)	32 (94.1)
Groin	9 (2.0)	24 (52.2)	33 (41.6)	28 (84.8)
Perineum	6 (1.3)	26 (56.5)	32 (42.9)	29 (90.6)
Axilla	1 (0.2)	8 (17.4)	9 (11.7)	8 (88.9)
Wound†	1 (3.2)	4 (66.7)	5 (13.5)	5 (100)
Vaginal‡	4 (2.6)	7 (36.8)	11 (6.5)	9 (81.8)

NOTE. Values are n (%).
MRSA, methicillin-resistant *Staphylococcus aureus*; *NA*, not applicable.
*Percent of USA300 positive out of total positive for each body site.
†Total of 37 individuals with a wound: 31 nares negative and 6 nares positive.
‡Total of 170 women: 152 nares negative and 19 nares positive.

Sex partners screening and MRSA status

We obtained data on 34 dyads (n = 68) to examine similarities and differences between partners and MRSA colonization. Ten couples (29%) had at least 1 partner who was colonized with MRSA in at least 1 body site. Four of the 10 couples were both partners positive for MRSA. All 4 of these subject-partner pairs (100%) shared the same strain type, and all were identified as USA 300 by PCR ESI-MS technology. Only 1 of the 4 MRSA-positive concordant couple was positive for colonization in several body sites: a woman was positive for vaginal, rectal, perineum, and groin, whereas her male partner was positive for the axilla and throat. The remaining 3 couples had the female partner positive at 1 body site (nares in 2, vaginal in 1), whereas the male partner was positive at multiple sites.

Risk factors for MRSA colonization

Unadjusted and multivariable models are presented in Table 3. In the unadjusted model, persons with the lowest annual income (<$25,000) had the greatest odds of colonization compared with those with the highest income (>$75,000) (OR = 3.96; 95% CI, 3.61-4.32). In the adjusted model, these relationships remained, but they were somewhat attenuated. Compared with the highest income (>$75,000), persons earning <$25,000 had 2.68 odds of colonization (95% CI, 2.33-3.08). Including race and income in the GEE model resulted in multicollinearity between the 2 variables. Further, the 1.13 odds of colonization among African Americans relative to Caucasians was not significant (95% CI, 0.67-1.90); therefore, race was removed from the final model.

Lower adjusted odds of colonization were associated sexual activity in the previous 12 months and use of highly active antiretroviral therapy. Participants who reported being sexually active within the prior 12 months had lower odds of MRSA colonization (adjusted odds ratio [AOR] = 0.84; 95% CI, 0.83-0.85). Taking HIV medication was associated with lower odds of MRSA colonization (AOR = 0.85; 95% CI, 0.75-0.96). In the unadjusted analysis, men

Table 3
GEE model results

Characteristics	Unadjusted model		Adjusted model	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Sex				
Male	0.61 (0.52-0.71)	<.0001	0.75 (0.53-1.05)	.0888
Female	Reference		Reference	
Education				
No high school or GED	2.34 (1.40-3.93)	.0013		
High school or GED	1.33 (0.80-2.21)	.2690		
Some college-vocational	1.57 (1.38-1.80)	<.0001		
College graduate or more	Reference			
Yearly income				
<$25,000	3.96 (3.61-4.35)	<.0001	2.68 (2.33-3.08)	<.0001
$25,001-$50,000	2.82 (2.37-3.37)	<.0001	2.50 (1.87-3.32)	<.0001
$50,001-$75,000	1.76 (1.32-2.34)	.0001	1.67 (1.35-2.06)	<.0001
≥$75,001	Reference			
Been arrested				
Yes	2.07 (1.92-2.23)	<.0001	1.55 (1.34-1.80)	<.0001
No	Reference		Reference	
Hands-on customer contact job				
Yes	0.33 (0.17-0.66)	.0017		
No	Reference			
Sexual orientation				
Different sex	1.73 (1.16-2.58)	.0077		
Same sex-both sexes	Reference			
Substance abuse (yes to street drugs)*				
Yes	1.69 (1.38-2.07)	<.0001	1.43 (1.38-1.48)	<.0001
No	Reference		Reference	
Sexually active*				
Yes	0.74 (0.60-092)	.0027	0.84 (0.83-0.85)	<.0001
No	Reference		Reference	
No. of sex partners in last 30 d				
0	1.22 (1.15-1.28)	<.0001		
1	Reference			
≥2	0.95 (0.47-1.90)	.8819		
Current or prior abscess†				
Yes	1.44 (1.09-1.91)	.0109	1.19 (1.17-1.20)	<.0001
No	Reference		Reference	
Hospitalized*				
Yes	1.91 (1.51-2.43)	<.0001	1.54 (1.22-1.94)	.0003
No	Reference		Reference	
HIV medication				
Yes	0.66 (0.54-0.80)	<.0001	0.85 (0.75-0.96)	<.0108
No	Reference		Reference	
On prophylaxis‡				
Yes	1.20 (1.08-1.33)	.0009		
No	Reference			
CD4 count				
<200	1.36 (1.22-1.52)	<.0001		
201-350	1.46 (1.03-2.06)	.0329		
351-500	1.16 (0.61-2.19)	.6556		
>500	Reference			

NOTE. Missing: hospitalized (n = 1), prophylaxis (n = 3), income (n = 2), and HIV medication (n = 4). Nonsignificant univariate results: race, on any type of isolation during hospitalization, and undetectable viral load. Nonsignificant multivariate analysis: sexual orientation, race, CD4 count, prophylaxis, number of sex partners, hands-on job, and education.

CI, confidence interval; *GED*, General Educational Development; *GEE*, generalized estimating equation; *MRSA*, methicillin-resistant *Staphylococcus aureus*; *OR*, odds ratio.

*Previous 12 months.

†Abscess groups combined to be current or history of abscess (yes/no). Reference group was no.

‡Prophylaxis for HIV-associated opportunistic infections includes any use of trimethoprim-sulfamethoxezole, dapsone, azithromycin, or fluconazole.

were less likely to be colonized with MRSA than women (AOR = 0.61; 95% CI, 0.52-0.71); however, this relationship did not remain in the final adjusted model (AOR = 0.75; 95% CI, 0.53-1.05).

Additional risks for MRSA were conferred for several attributes. Those who had been arrested were 55% more likely to have MRSA colonization (AOR = 1.55; 95% CI, 1.34-1.80). Using street drugs in the previous 12 months conferred independent additional risk for MRSA infection (AOR = 1.343; 95% CI, 1.38-1.48). Participants with a history of abscess, with a current abscess (AOR = 1.19; 95% CI, 1.17-1.20), or having been hospitalized (AOR = 1.54; 95% CI, 1.22-1.94) were also significantly more likely to be colonized with MRSA.

DISCUSSION

MRSA is a preventable infection that can lead to significant morbidity and mortality among PLWH. The findings from the present study provide new information about risk factors for MRSA colonization and are particularly relevant to the ongoing debate regarding body site colonization and sexual acquisition among this vulnerable population. Colonization of the groin in particular has been associated with skin and soft tissue infections,[19] suggesting the importance of the anatomic site of colonization in setting surveillance and treatment priorities. In the present study, we found that 40.3% of all MRSA-colonized individuals were culture negative

in the nares, suggesting that surveillance of the nares alone can miss substantial MRSA colonization among PLWH and may contribute to both transmission in hospital and community settings.

Being sexually active in the previous 12 months was found to lower the odds of MRSA colonization, suggesting that other means of acquisition may play a greater role in transmission in our study population. Comparing those reporting sexual activity with sexually inactive individuals, we found significant differences ($P = .041$) in the proportion with CD4+ T cell counts >500 (50.3 vs 41.5, respectively) and <200 (10.1 vs 14.6, respectively). Consequently, sexually active individuals may be in better overall health, therefore providing one possible explanation of the protective effect of this characteristic. Four of the 10 sexual partner pairs were found to carry the same strain, indicating likely household transmission.

Although several recent studies report increased MRSA transmission among men who have sex with men populations,[3,4,6] we did not find an association with same-sex coupling when adjusting for other risk factors. The loss of a significant association may have been a consequence of confounding by other factors. Two-sided Fisher exact tests were performed to examine associations with sexual orientation. Compared with heterosexual orientation, those reporting same or both sex orientation were more likely to be sexually active (76.8% vs 61.1%, $P = .001$) and report an annual income >$75,000 (16.9% vs 8%, $P < .001$), both of which were protective in adjusted analysis. Compared with same or both sex orientation, heterosexual orientation was positively associated with substance abuse (29.2% vs 11.9%, $P < .001$) and being hospitalized (32.2% vs 22.2%, $P < .010$) or arrested (10.1% vs 4.3%, $P < .025$) in the previous 12 months, which were risks for colonization in adjusted analysis. Lack of association in multivariate analysis for multiple sex partners may be influenced by low prevalence (n = 37, 7.4%) and underreporting related to social desirability bias. Age and race were not associated with increased MRSA colonization.

Use of HIV antiretroviral therapy (ART) lowered the odds of MRSA colonization. Although several studies have looked at use of ART as a risk factor for MRSA,[21] 3 of the 4 studies that found any association did so only in univariate analyses.[20,22,23] Only 1 study showed significance in a multivariate analysis, with a reduced odds of MRSA infection when taking ART.[11] Our findings suggest that receiving ART may lower the odds of colonization as well.

Clinical indicators of immune status, viral load, and CD4 count were not found to be significantly associated with MRSA colonization. It may be that being on ART was a surrogate indicator of greater engagement in outpatient primary care and fewer encounters with hospitals and other acute health care settings where contact with and transmission of MRSA can occur. Greater engagement in primary care, which enhances primary prevention, may be protective of MRSA colonization regardless of the stage of HIV disease.

Studies of MRSA surveillance within general populations have found a greater proportion identified with the nares alone compared with our study in PLWH and confirmed that sampling multiple anatomic sites greatly increases screening sensitivity. Within general populations on hospital or intensive care unit admission, nares cultures were identified from only about 66%[24] to 81.5%[25] of all MRSA-colonized patients. Sensitivity analysis has shown that sampling multiple sites can increase yield with nares and perineum to 89.6%[26] and with nares, throat, and groin screening to 98%.[27] Screening nares only when MRSA prevalence is low (<6%) yields 68% of all colonized patients; with high prevalence it yields 73%; and in the intensive care unit it yields 75%.[28] Even with a very high (15.4%) prevalence in our study of PLWH, the proportion identified through nares alone (58.9%) was much lower than proportions identified in the general population. It is clear that among PLWH, screening multiple body sites is of even greater importance.

MRSA colonization remains common among PLWH, and predictors of colonization are highly variable depending on the clinical context and study sample characteristics. We found clear differences in a number of socioeconomic and health indicators between the 2 clinic sites as seen in Table 1. The GSS serves a primarily white, more-educated, male population with higher incomes and greater CD4+ T cell counts compared with the Moore Clinic's primarily inner-city, black, less-educated clients with lower incomes and lower CD4+ T cell counts. However, the choice of the GEE method for modeling associations can help to account for intraclinic correlations. In addition, both clinics are part of the same medical service and share the same clinicians, which likely limits differences in service delivery as a factor in the associations we found.

In this cross-sectional analysis, we identified the importance of multibody site evaluation in this patient population and uncovered additional risk associated with colonization in this group. It is time for hospital epidemiologists and infection preventionists to reconsider surveillance approaches for populations known to have a high colonization prevalence for MRSA.

Limitations

Although robust estimation of SEs was used in fit of the GEE models, the small number of clinic sites likely resulted in an underestimation of the SEs. Using a cross-sectional method, this study examined prevalence of MRSA at a single point in time and does not account for changing relationships among risk factors and MRSA acquisition over time. We attempted to reduce the likelihood of providing socially desirable responses, particularly regarding drug use and sexual behaviors, by using previously implemented survey questions, providing a private interview location, and confirming confidentiality of responses. To control for this potential bias, respondent answers were verified by medical record review and abstraction. Sample size was determined based on an estimated 18% prevalence of current abscess; however, prevalence in the study sample was 7.8% overall. Consequently, our ability to detect smaller effect sizes and the likelihood that statistically significant associations reflect true effects may be limited.

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